Indiana Natural Gas Modeling System: A Technical Report

Presentation to

Indiana Utility Regulatory Commission

Gas Price Forum

State Utility Forecasting Group
Purdue University

July 10, 2003

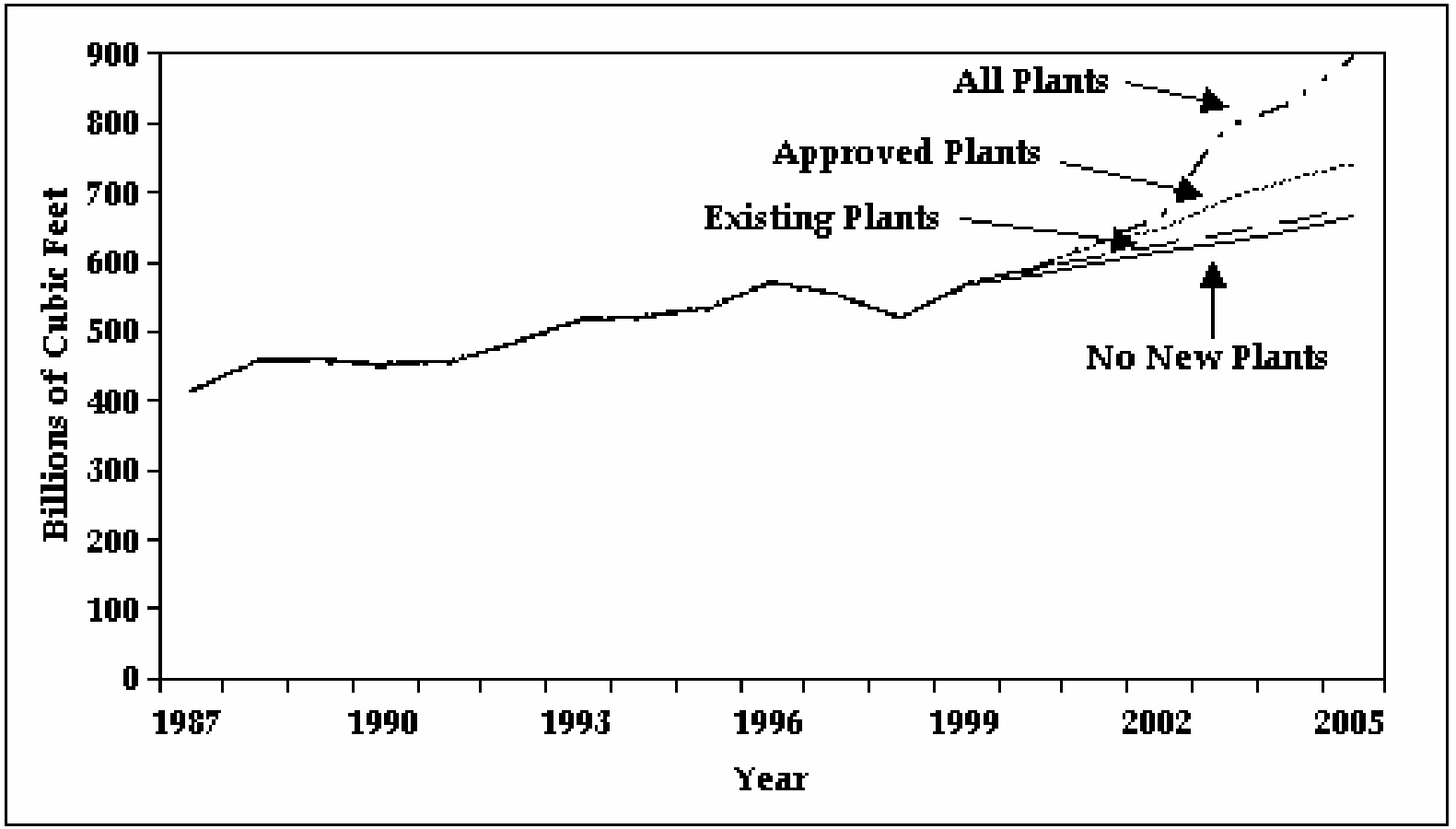
SUFG'S NATURAL GAS MODELING SYSTEM

- SUFG has been developing a natural gas model in order to investigate the impact of new natural gas-fired generators on the gas transportation, distribution, and storage system
- A technical report was released earlier this month and is available on the SUFG website:

  https://engineering.purdue.edu/IIES/SUFG
- The report is not a forecast and does not provide projections of future use and prices
- The report is intended to inform industry experts of the model's structure and capabilities in order to get constructive feedback for future model improvements

OBJECTIVE

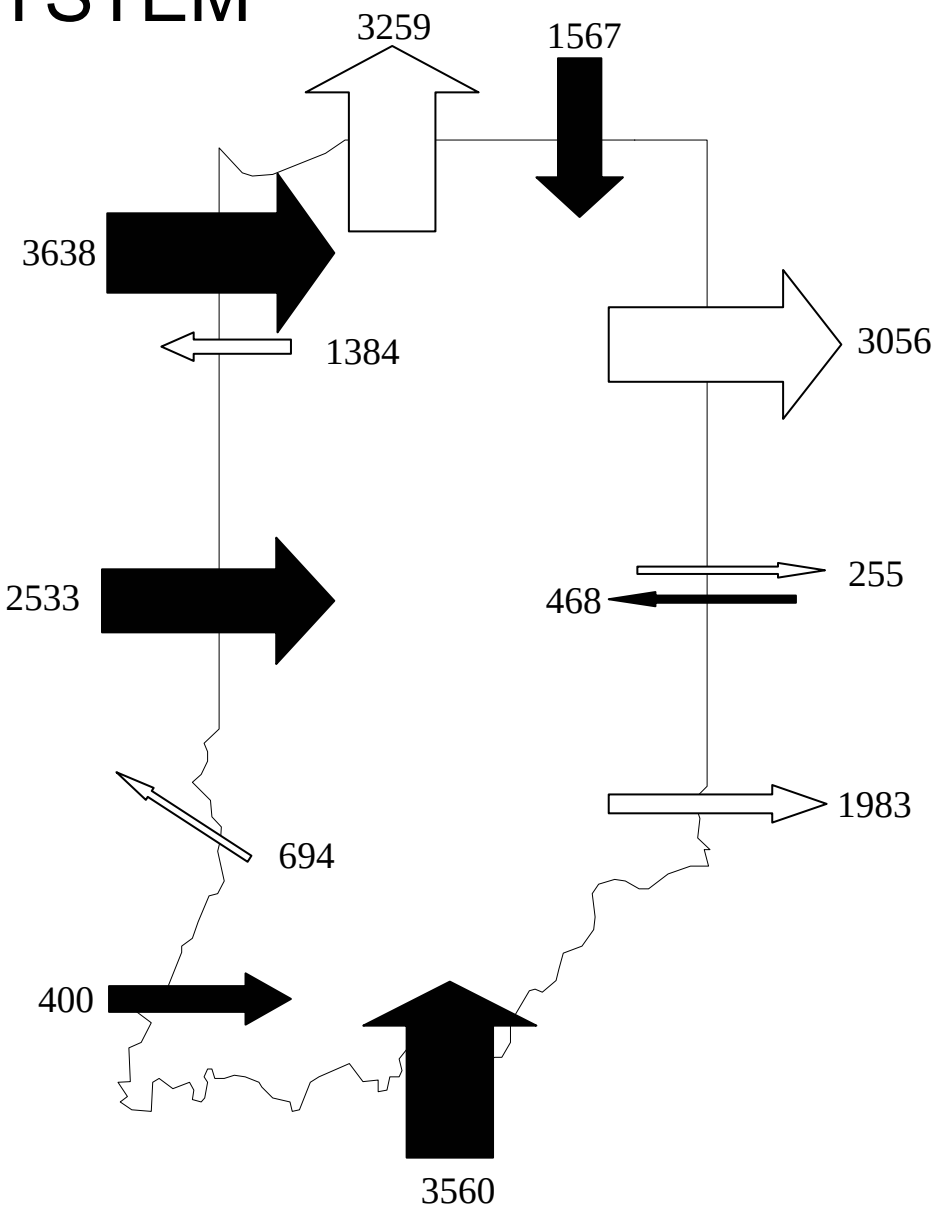
To study the impact of new gas fired electricity generating facilities on the gas system.



INDIANA'S NATURAL GAS TRANSPORTATION SYSTEM

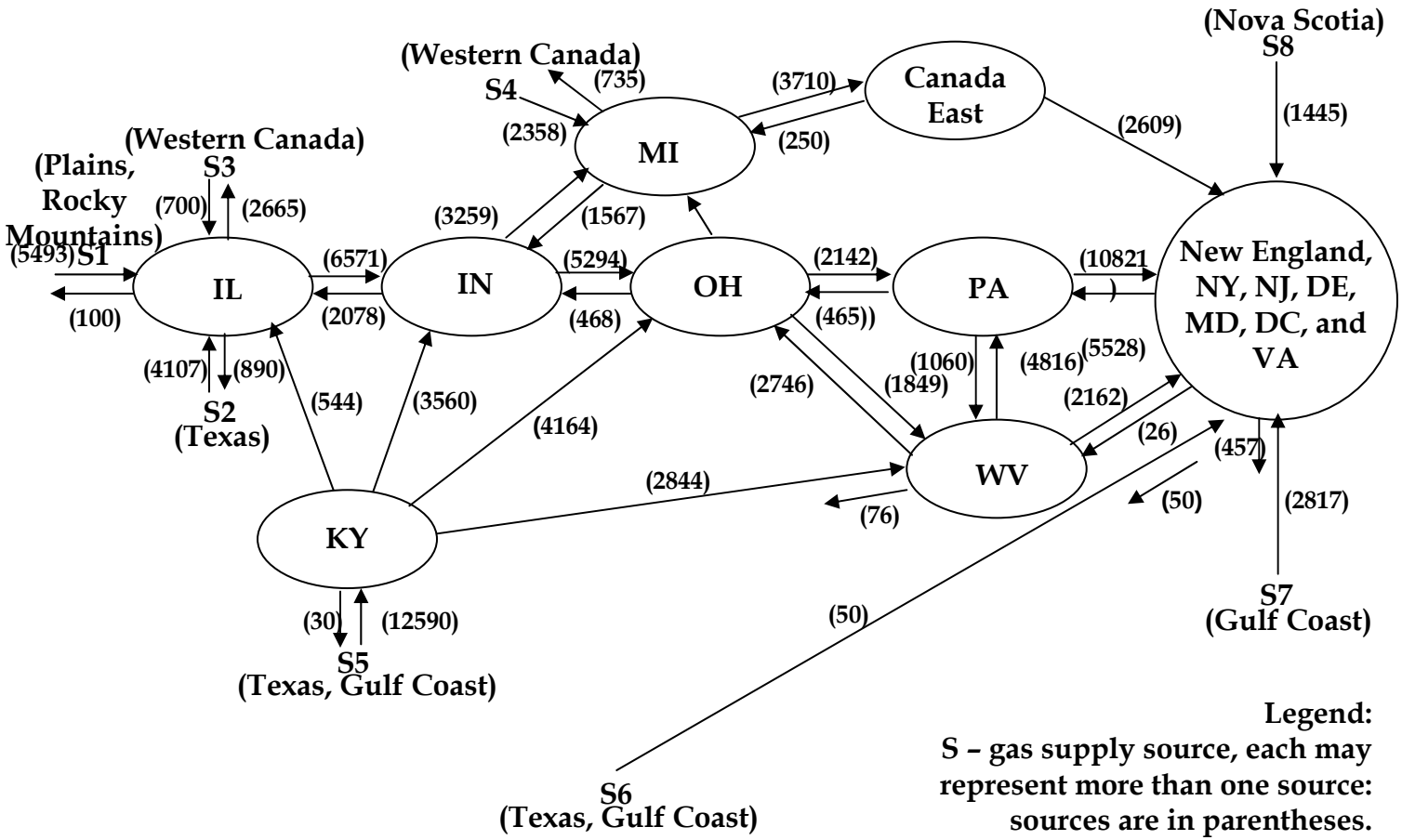
- Over 70 percent of the gas entering the state is sent further downstream to serve customers in the Northeast

- Indiana's pipeline system is sized to handle a larger flow than Indiana's native demand (about 3,000 mmcf per day in the peak heating season)



NECESSARY TO MODEL MORE THAN INDIANA

(Numbers in parentheses show total pipeline capacities between nodes in mmcf/d)



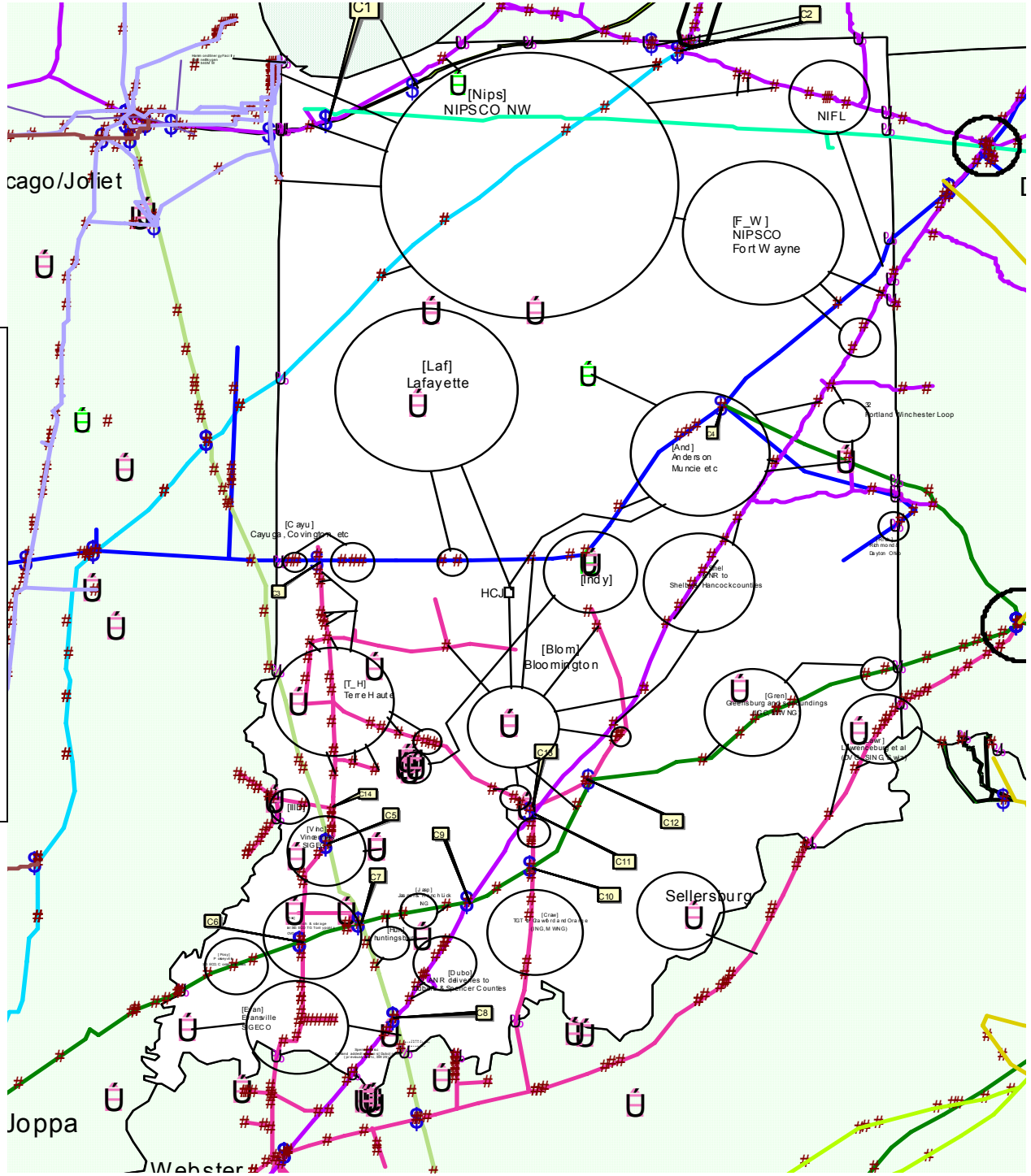
Note: This includes the capacities of planned additions to the system over the planning horizon.
Source: EIA, December 2002

Indiana modeled in more detail

Total nodes in model 87

Indiana nodes 69
demand nodes 23

U-shaped symbols are storage locations
Brown # are city gates points
Blue $ are pipeline interconnections



AN OPTIMIZATION MODEL

- Minimize the total cost of meeting the demand less any local production

- Cost of gas at the source nodes
  Cost of moving gas to the city gates
  Cost of storage

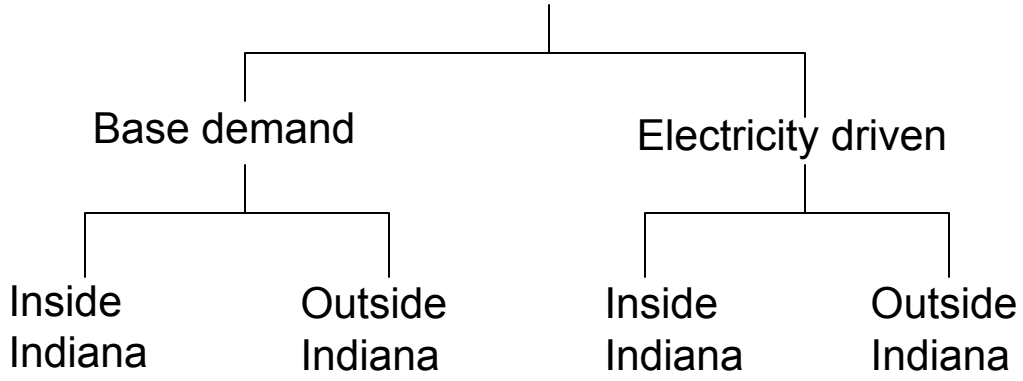
- While respecting the system physical constraints
  pipeline capacities (including all known additions)
  storage capacities

- The smallest unit of time modeled is a month

DATA REQUIREMENTS

Forecasts

Demand forecast



Supply price forecast

Local gas production forecast

Capacities

Interstate pipeline capacities
Plus a few LDC limiting capacities
e.g. Hendricks County Junction

Storage capacities

Costs

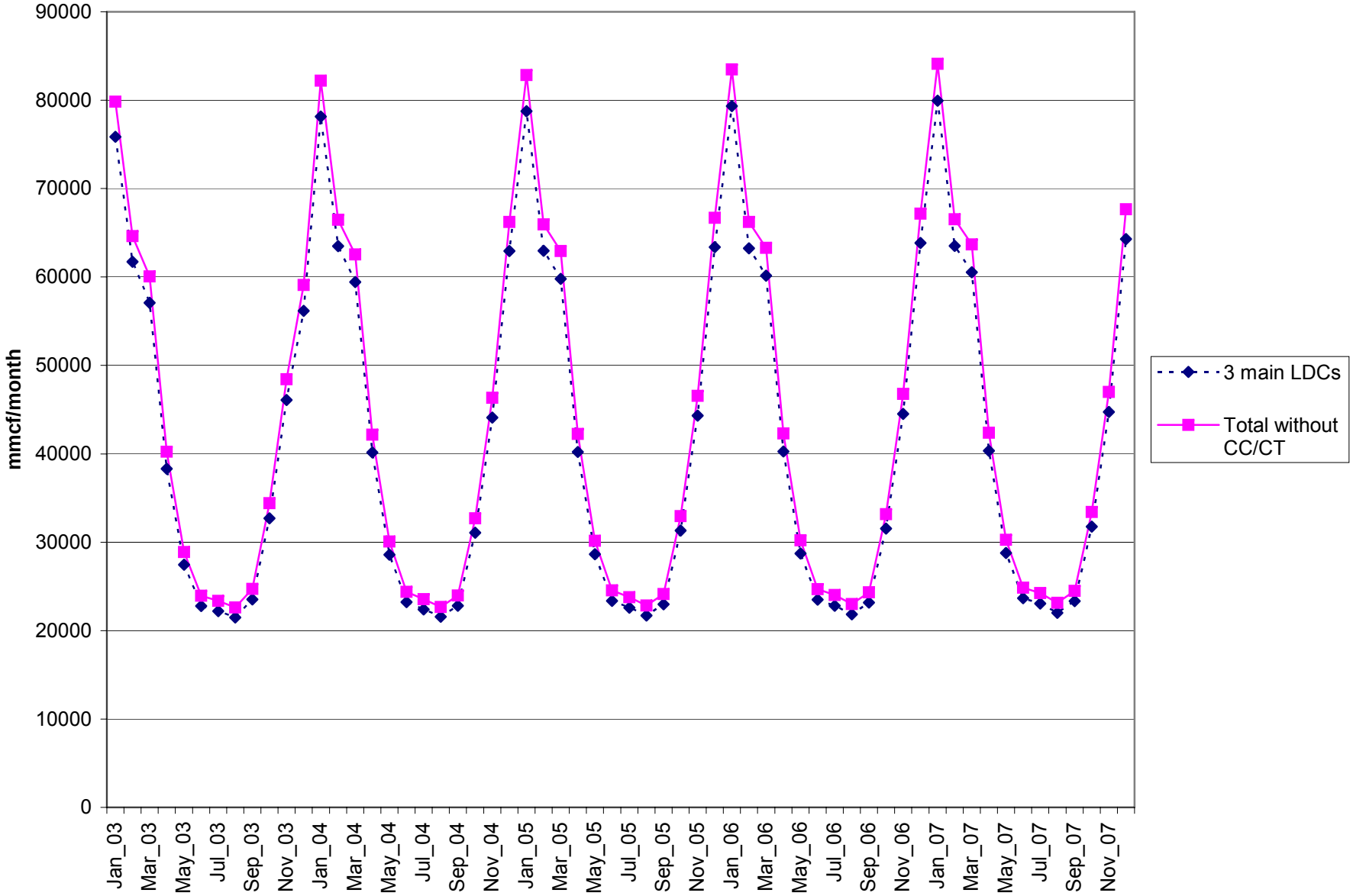
Cost of transporting gas

Cost of storing gas

FORECASTING INDIANA'S BASE DEMAND

- The four main Indiana LDCs (CGCU, NIPSCO, IGC, SIGECO) provided historical consumption data
- SUFG built a linear regression model for each month with CDD, HDD as explanatory variables and a trend to arrive at a base forecast
- The ~5% demand not covered by the 4 major LDCs was estimated using the flow data from the EIAGIS-NG system

INDIANA DEMAND PROJECTION



BASE GAS DEMAND FORECAST OUTSIDE INDIANA

- Linear regression
- EIA historical monthly demand 1989 – 2000
- Explanatory variables are HDD, CDD, price and a trend variable
- Good statistical fit obtained ($R^2 \approx 0.9$)

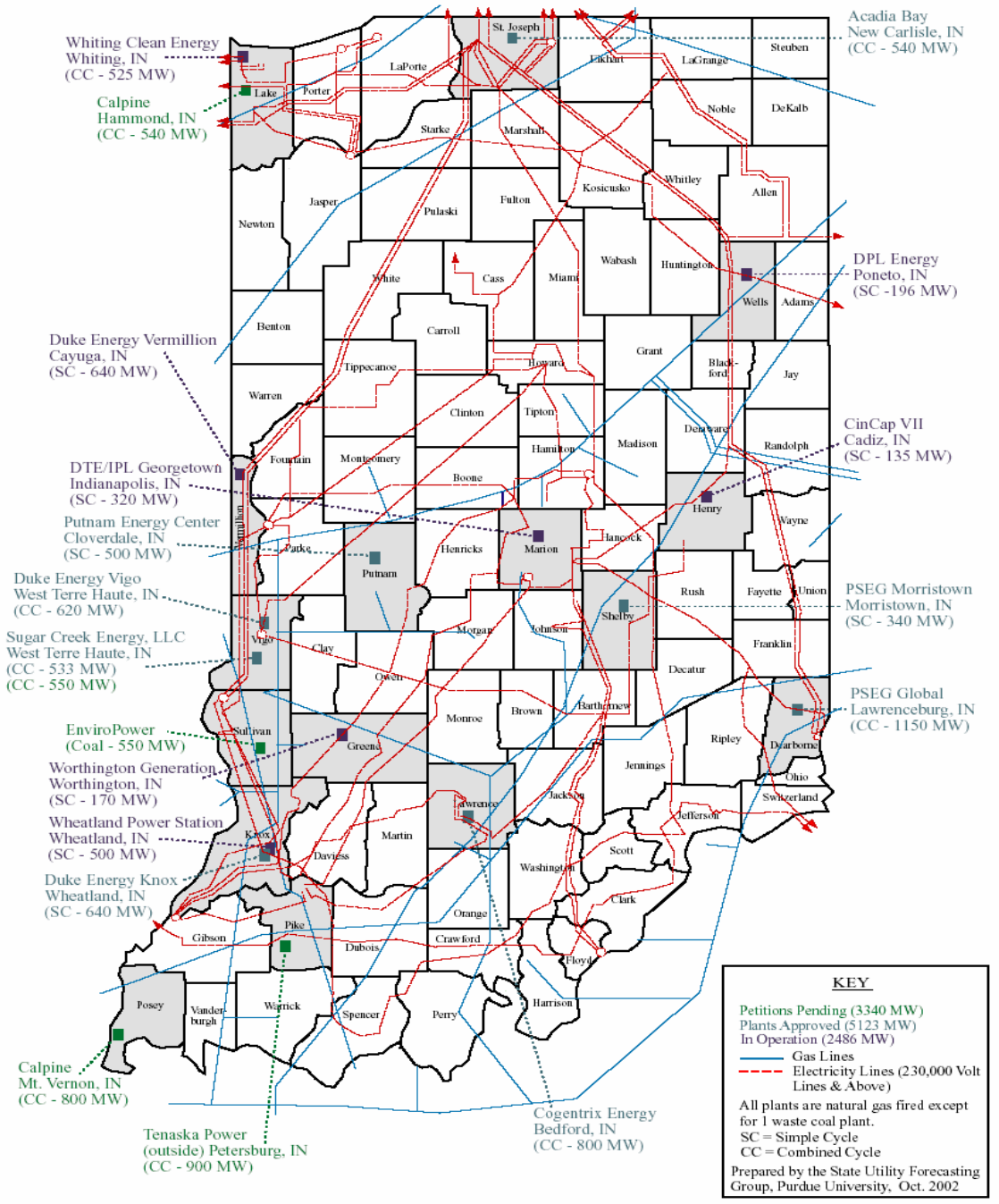
Electricity driven gas demand inside Indiana

CC/CT assumed to run as follows

- Hours assumed
  50% of the hours in each month throughout the year for CC

  a total of 874 hours in an year mostly during the summer peak for CT

- Heat rate (Btu/kWh)
  7340 for CC
  11,000 for CT



ELECTRICITY DRIVEN GAS DEMAND FORECAST OUTSIDE INDIANA

- SUFG assumes gas consumption by CC/CT's will be driven by electricity demand growth rather than the number of merchant plants built
- 1.8% electricity demand growth assumed for the base case
- All the electricity growth will be met by CC/CT's
- An electricity dispatch model is used to allocate the share of demand met by CC vs. CT

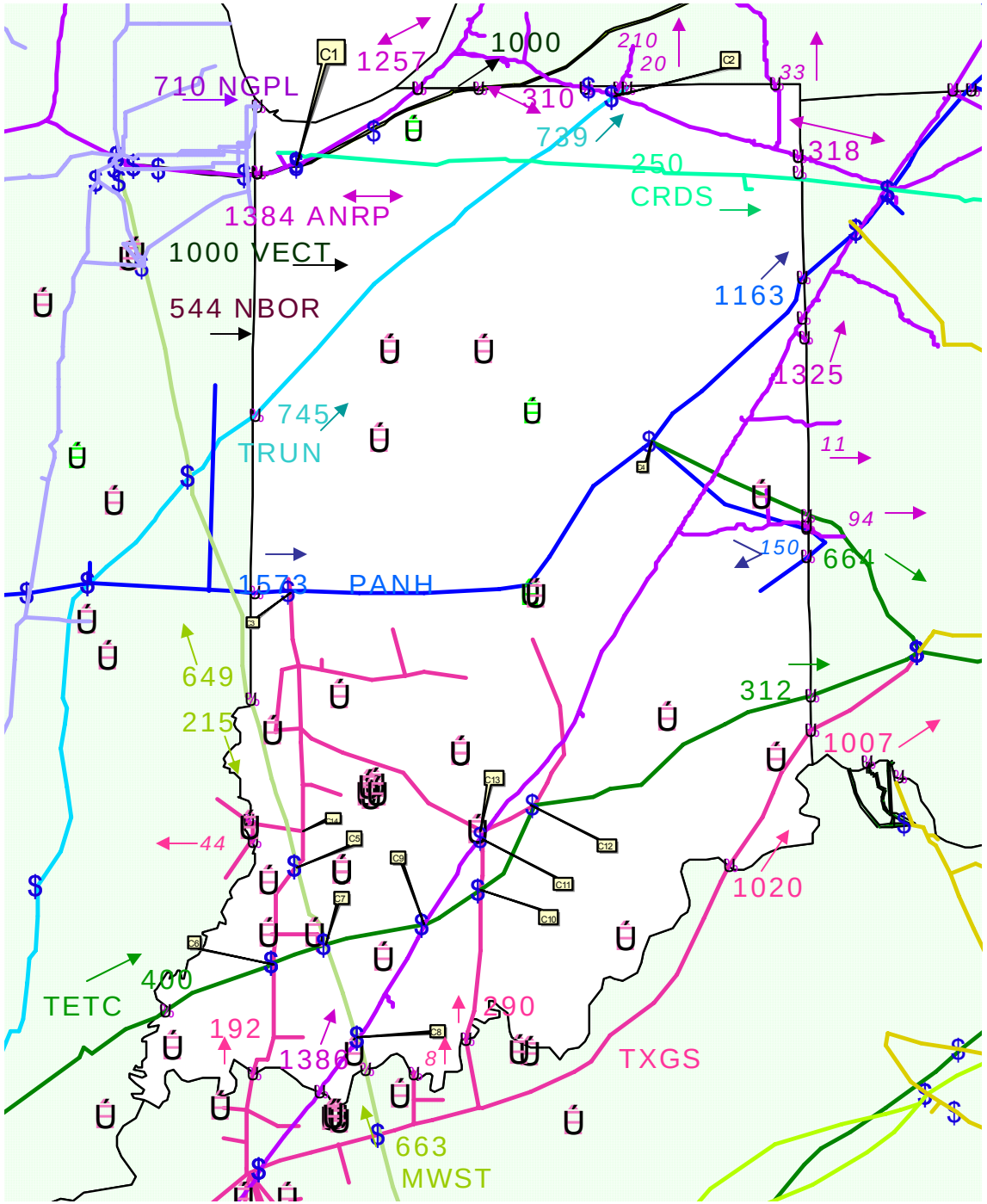
GAS SUPPLY PRICE FORECAST FROM EIA

- EIA 2001 annual wellhead price forecast adjusted for actual observations in 2002
- Annual forecast broken into monthly forecasts using historical monthly distribution factors
- Transportation rates added to the wellhead price forecasts to create price forecasts at the boundary of the model
- Prices at the model's source nodes are a weighted average of the wellhead price plus transportation cost for several points of origin

Interstate pipelines serving Indiana

Into Indiana = 12,166 mmcf/d
Out of Indiana = 10,631 mmcf/d

NGPL – Natural gas pipeline co of America
ANRP – ANR pipeline co
CRDS – Crossroads pipeline co.
VECT – Vector pipeline co.
NBOR - Northern border pipeline co.
PANH - Panhandle eastern co.
TRUN – Trunkline gas co.
TETC – Texas eastern transport co.
TXGS – Texas gas transmission co.
MWST – Midwestern gas transmission co.

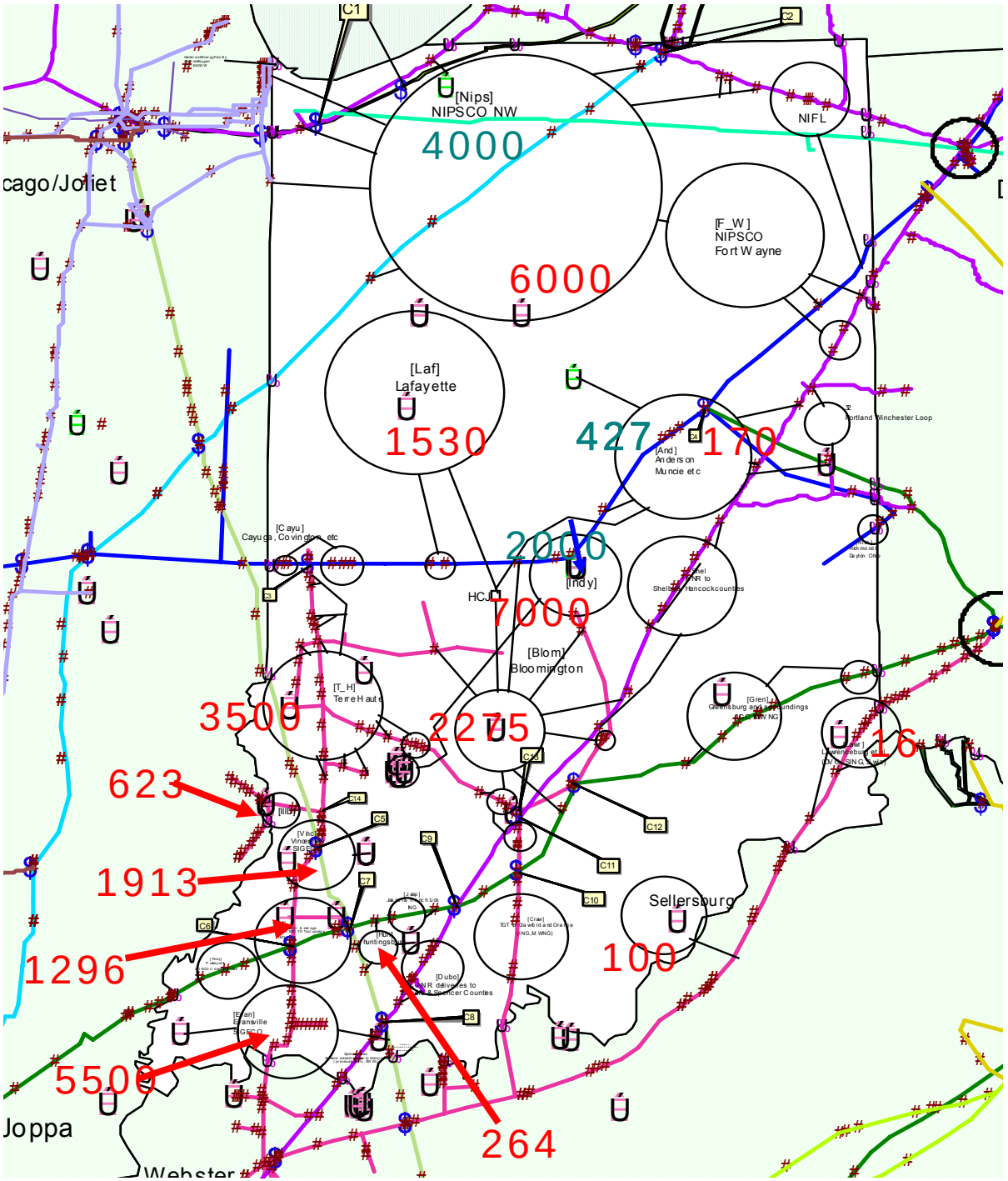


Indiana storage working capacity (mmcf)

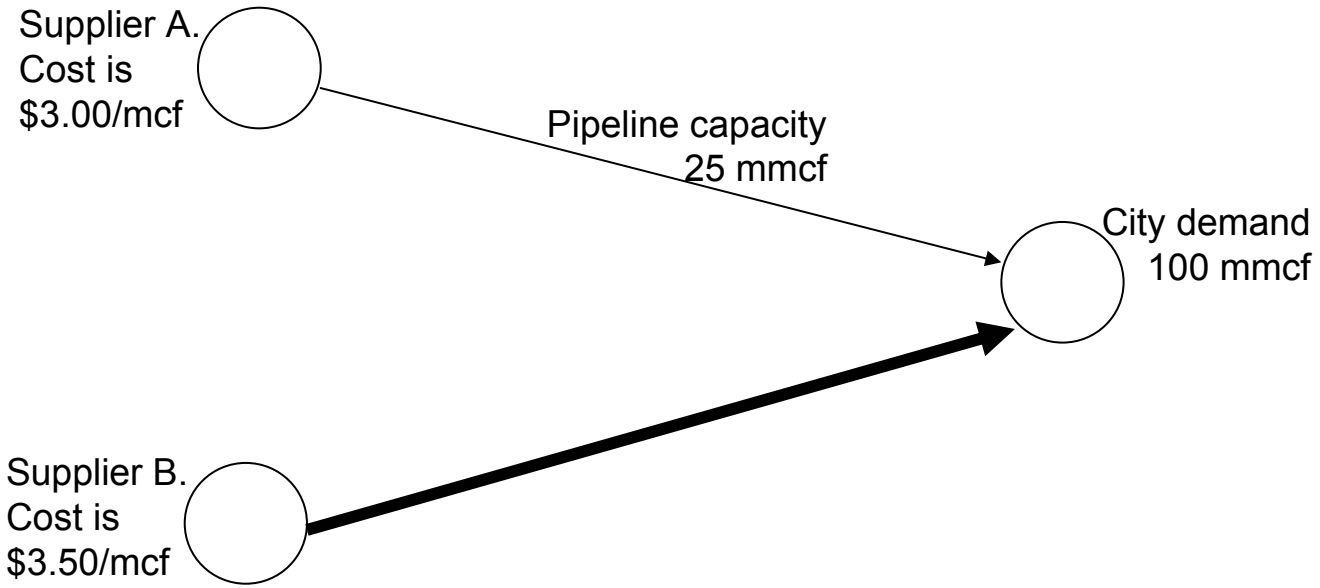
Underground	
★	Field location
1530	Node capacity

LNG	
★	Facility location
427	Node capacity

Indiana total	**36814**
Underground =	30387
LNG =	6427



PHYSICAL VS. ECONOMIC CONGESTION



Case 1 – physical congestion
if pipeline capacity from B is 70 mmcf

Case 2 – economic congestion
if pipeline capacity from B is 100 mmcf

THE EXPERIMENTS

1. Average regional demand
   a) base case – average demand plus merchant plants currently *in operation*
   b) base case plus *all proposed merchant* plants in Indiana.

2. Above average regional demand
   a) with only merchant plants currently *operating* in Indiana
   b) plus *all proposed merchant* plants in Indiana.

3. Outage at a major pipeline interconnection
   a) forced outage
   b) planned outage at same interconnection

4. Free gas exchange at the interconnections inside Indiana

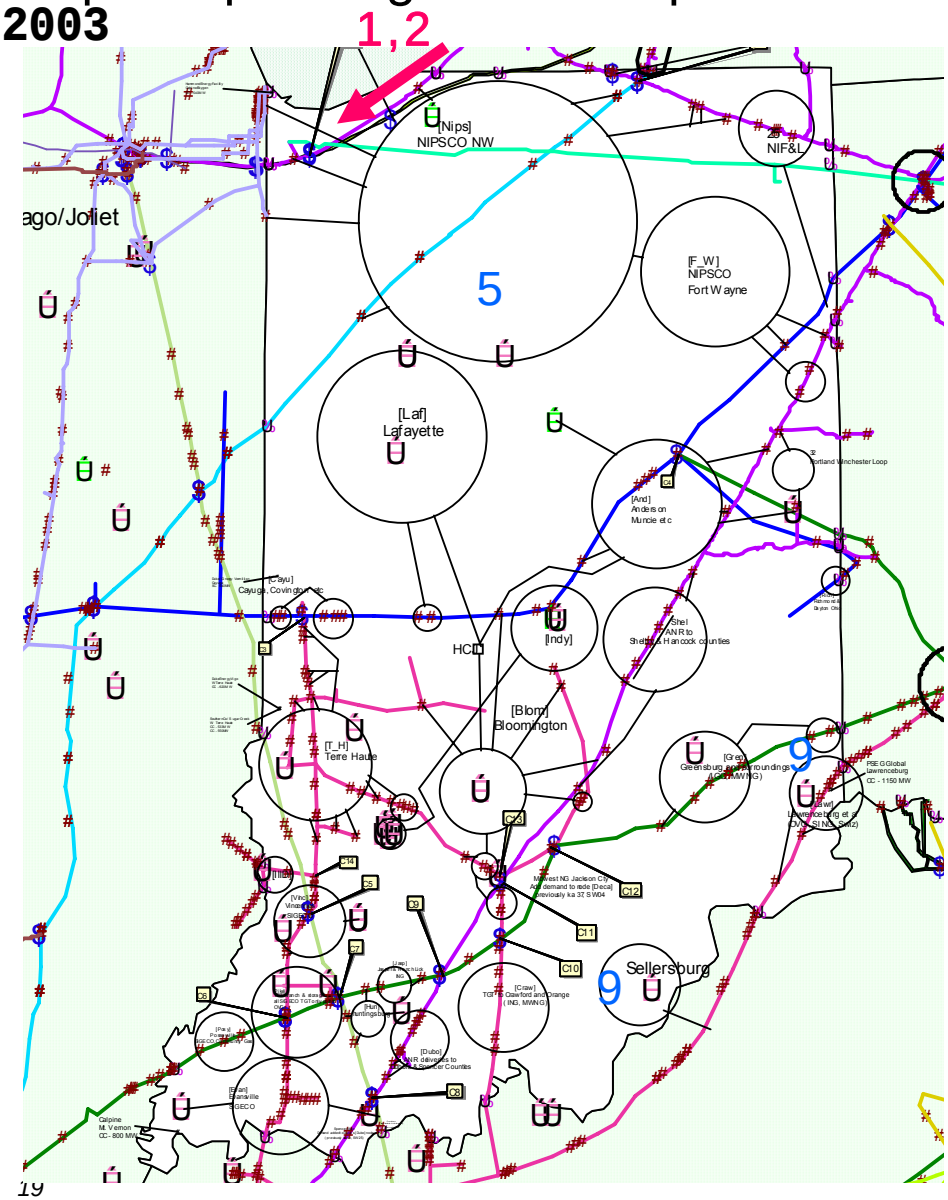
5. Extreme weather
   a) with only merchant plants currently *operating* in Indiana
   b) plus *all proposed merchant* plants in Indiana.

Base case -
Average demand
plus operating merchant plants

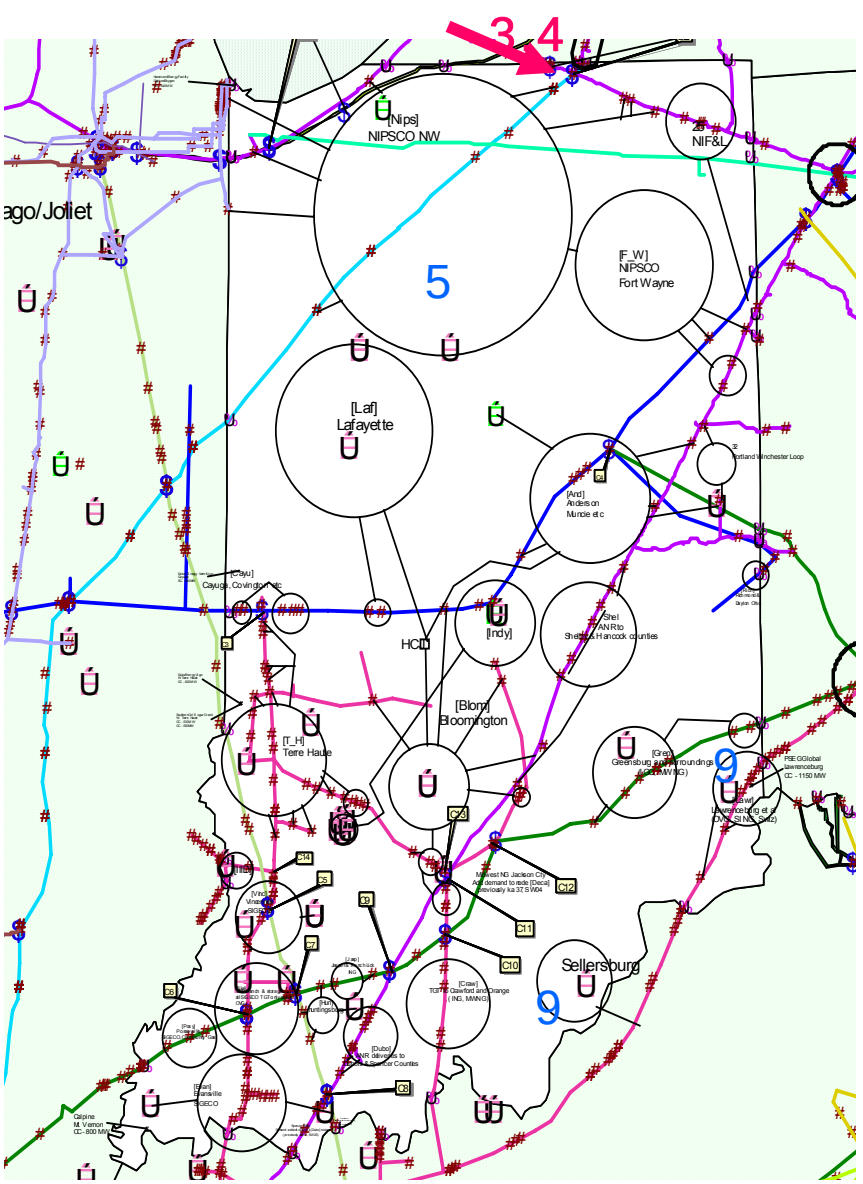
525 MW CC in node NIPSCO_W

640 MW CT in node Cayuga
320 MW CT in node Indianapolis
196 MW CT in node Anderson
170 MW CT in node Terre Haute
135 MW CT in node Shelby
500 MW CT in node Vincennes

2003



2004



Base case (continued)

525 MW CC in node NIPSCO_W

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320 MW CT in node Indianapolis
196 MW CT in node Anderson
170 MW CT in node Terre Haute
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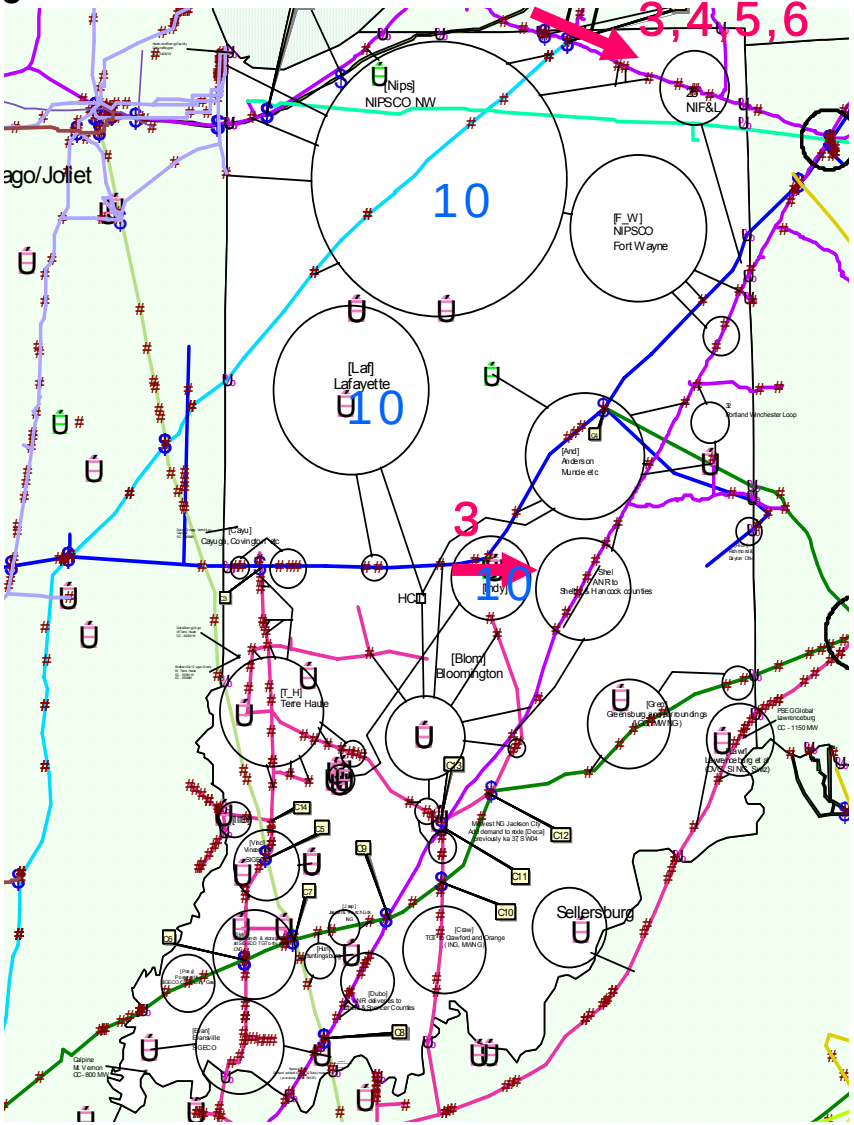
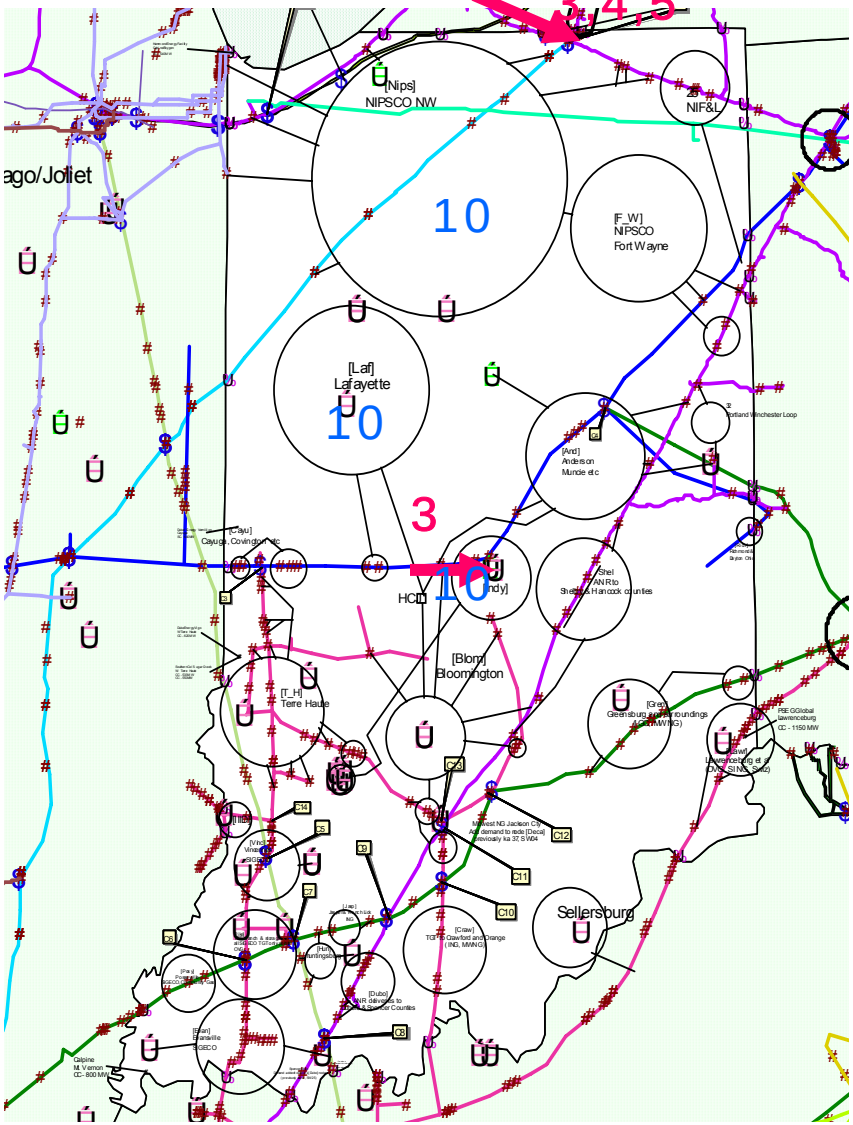


2006

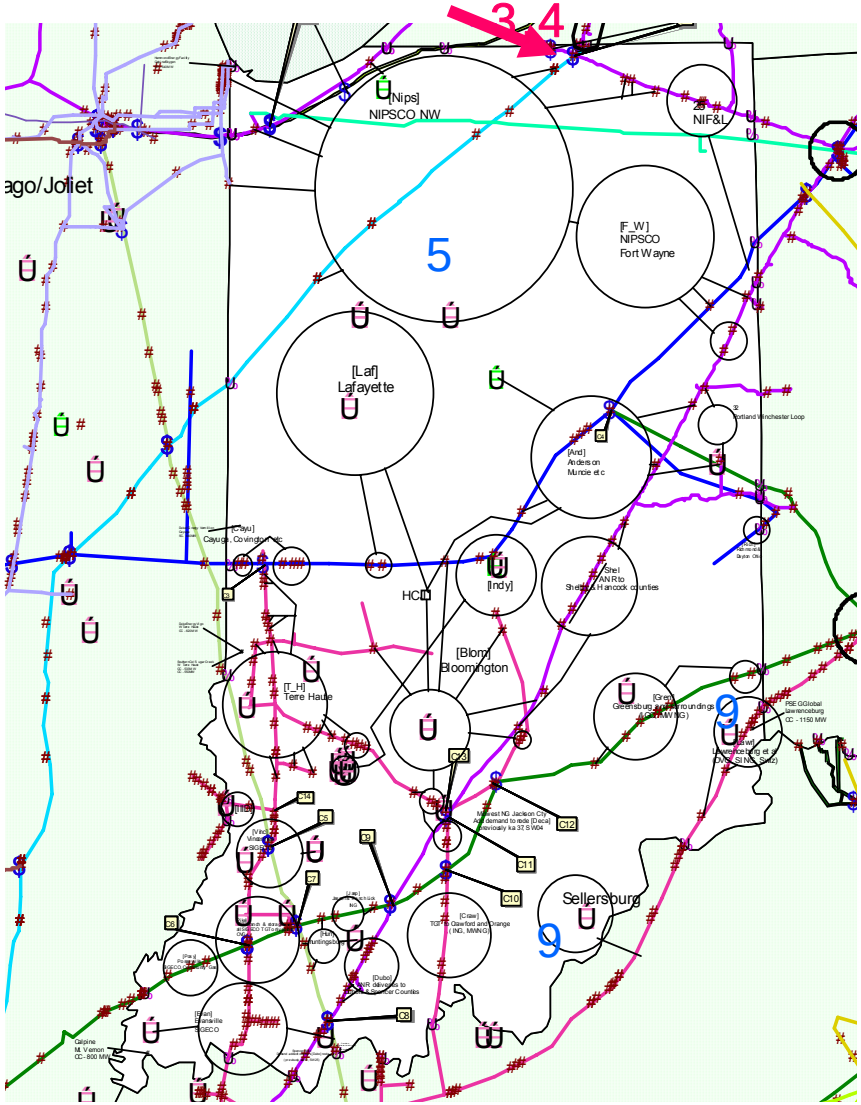


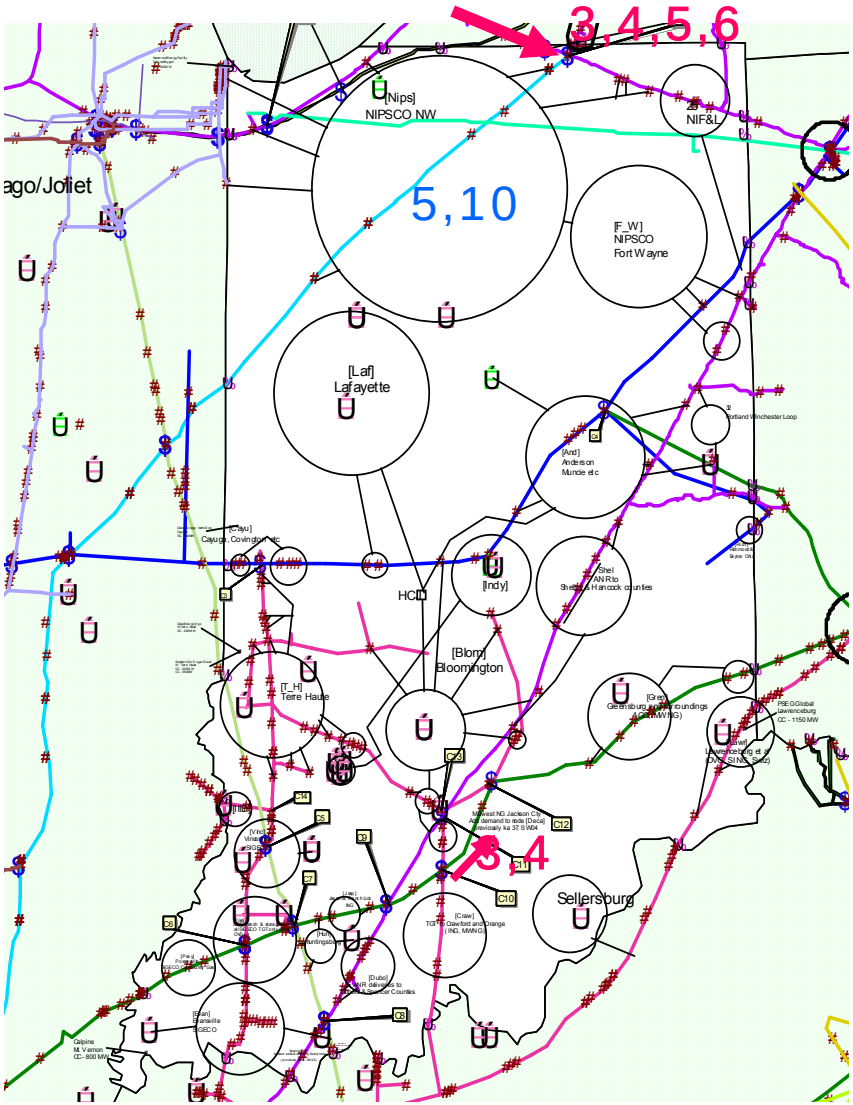
2004

Base case

Plus all proposed CTs and CCs in Indiana

Generators added in 2004
1153 MW CC in node Terre Haute
800 MW CC in node Bloomington
1150 MW CC in node Lawrenceburg
340 MW CT in node Shelby

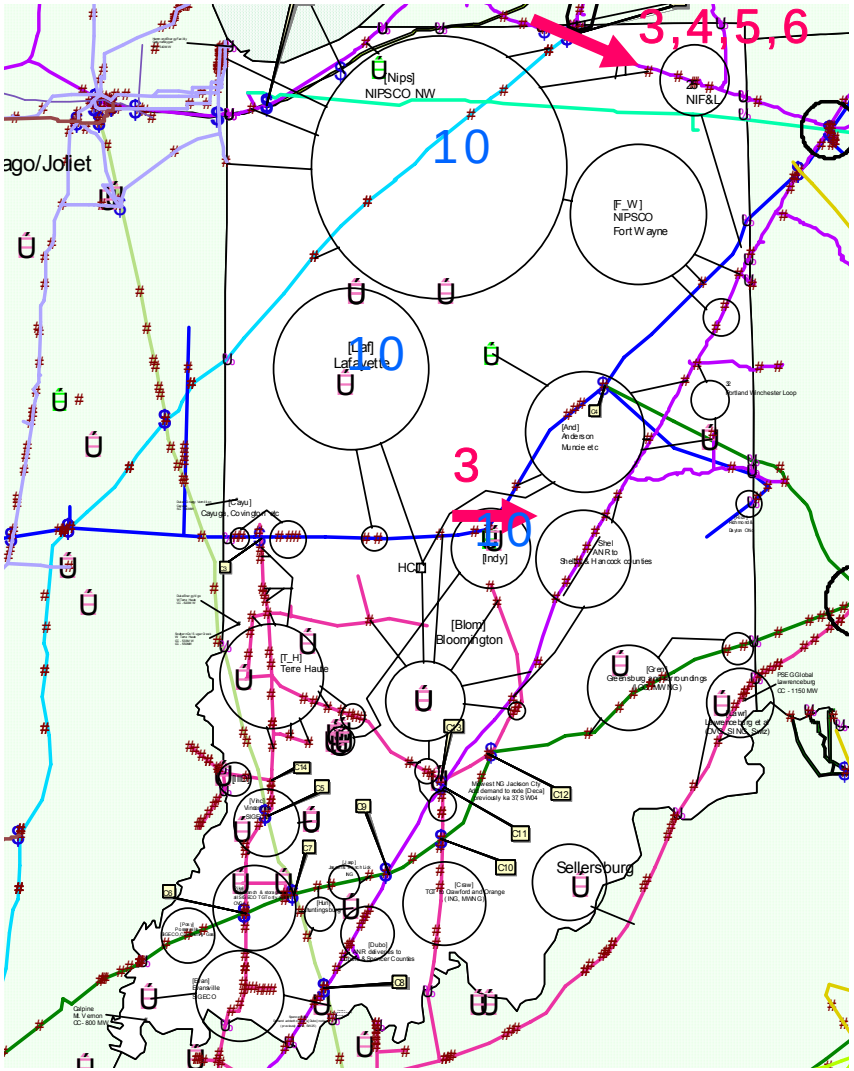


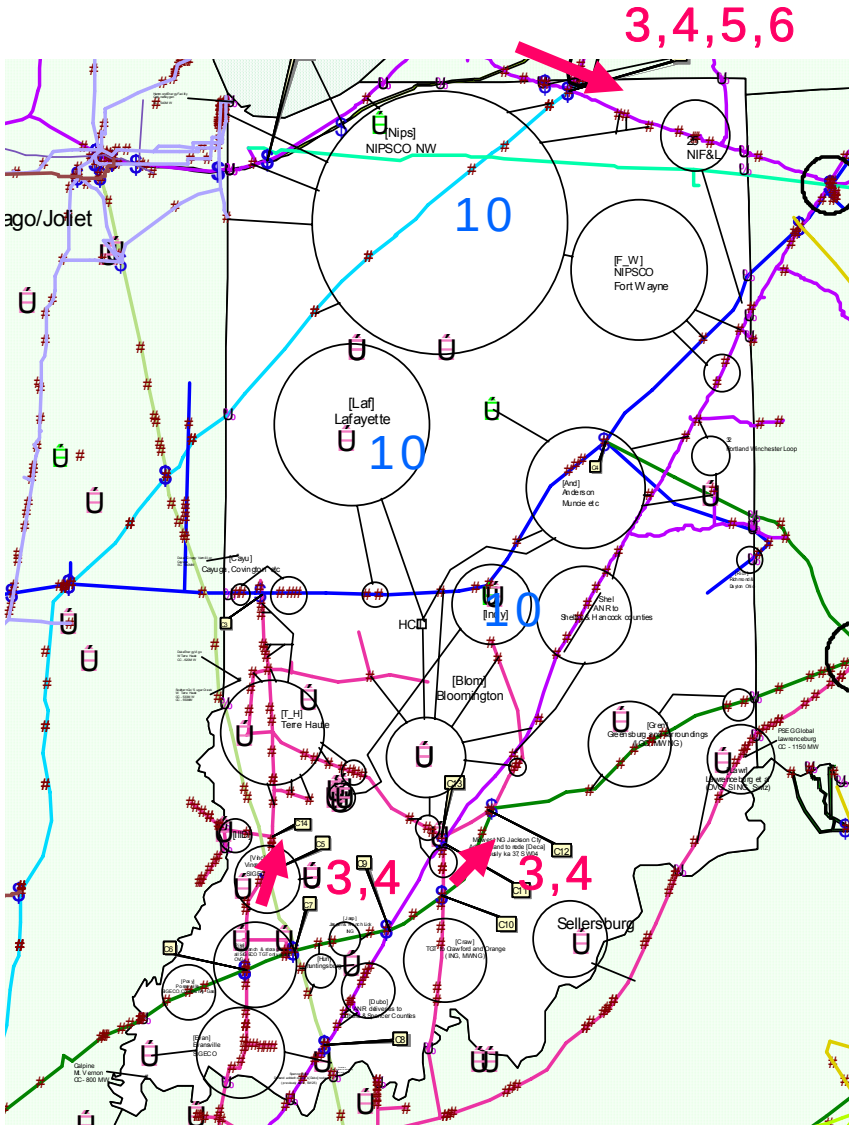


2005 **Base case**

Plus all proposed CTs and CCs in Indiana

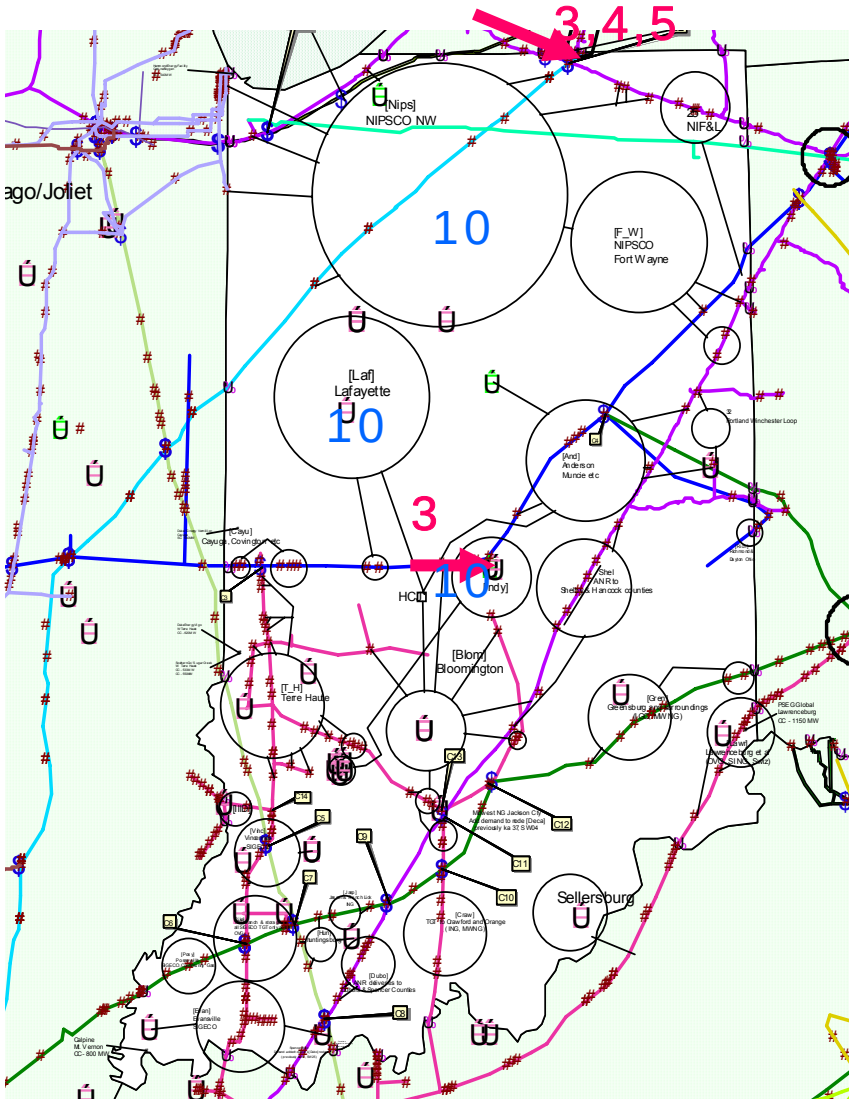
Generators added in 2005
550MW CC in node Terre Haute
900MW CC in node pike
800MW CC in node Evansville





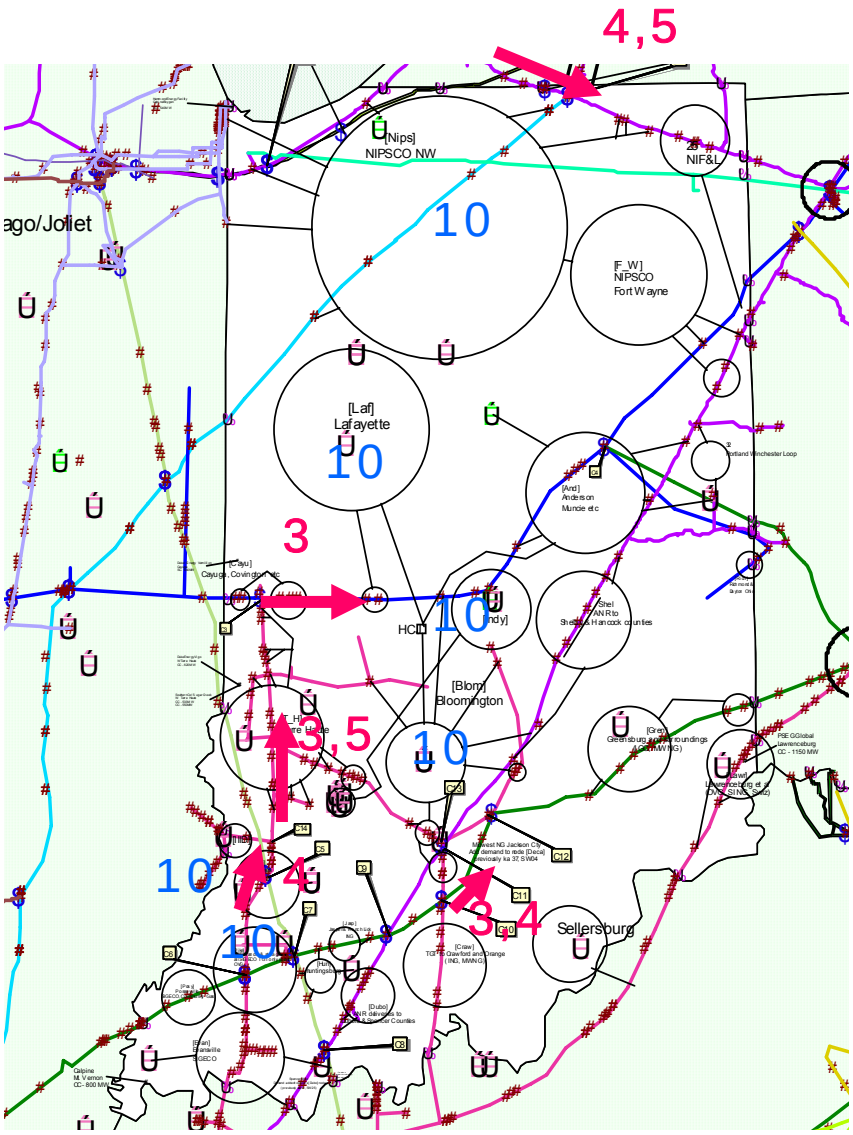
2006

Base case



Plus all proposed CTs and CCs in Indiana

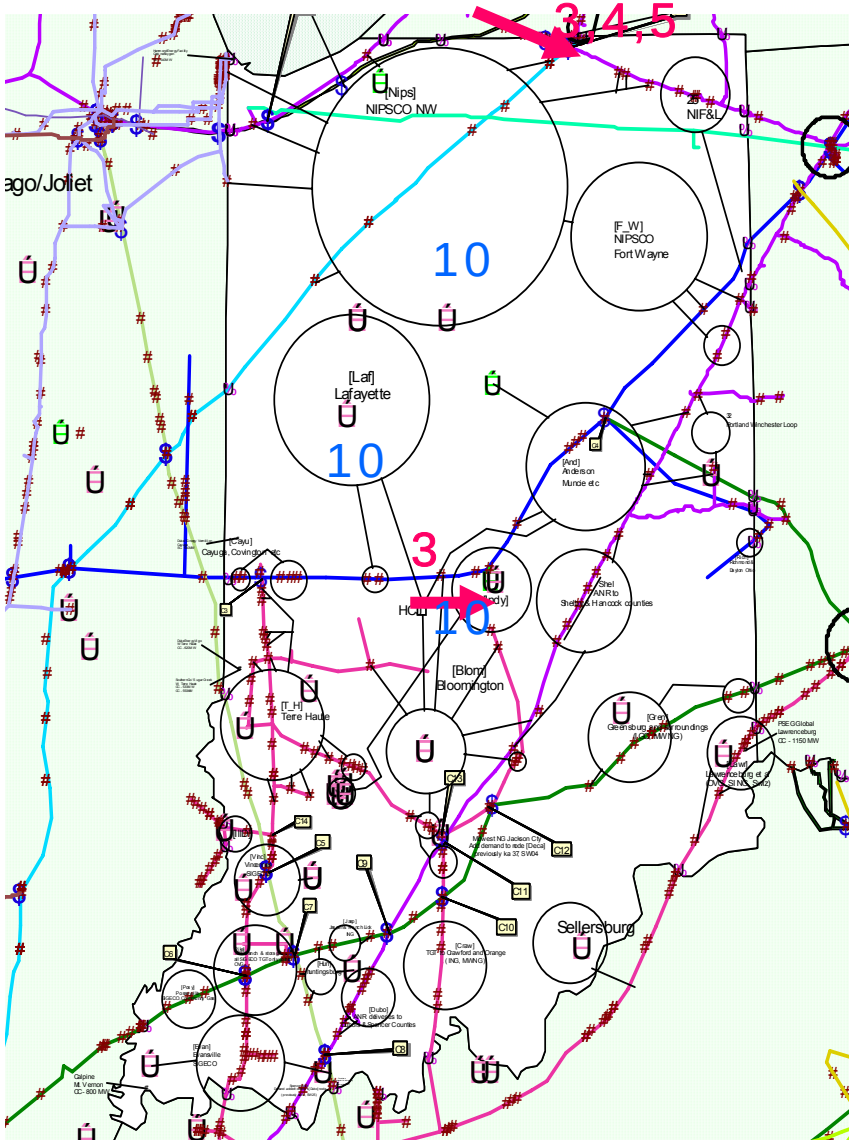
Generators added in 2006
540MW CC in node NIPSCO_NW



2006

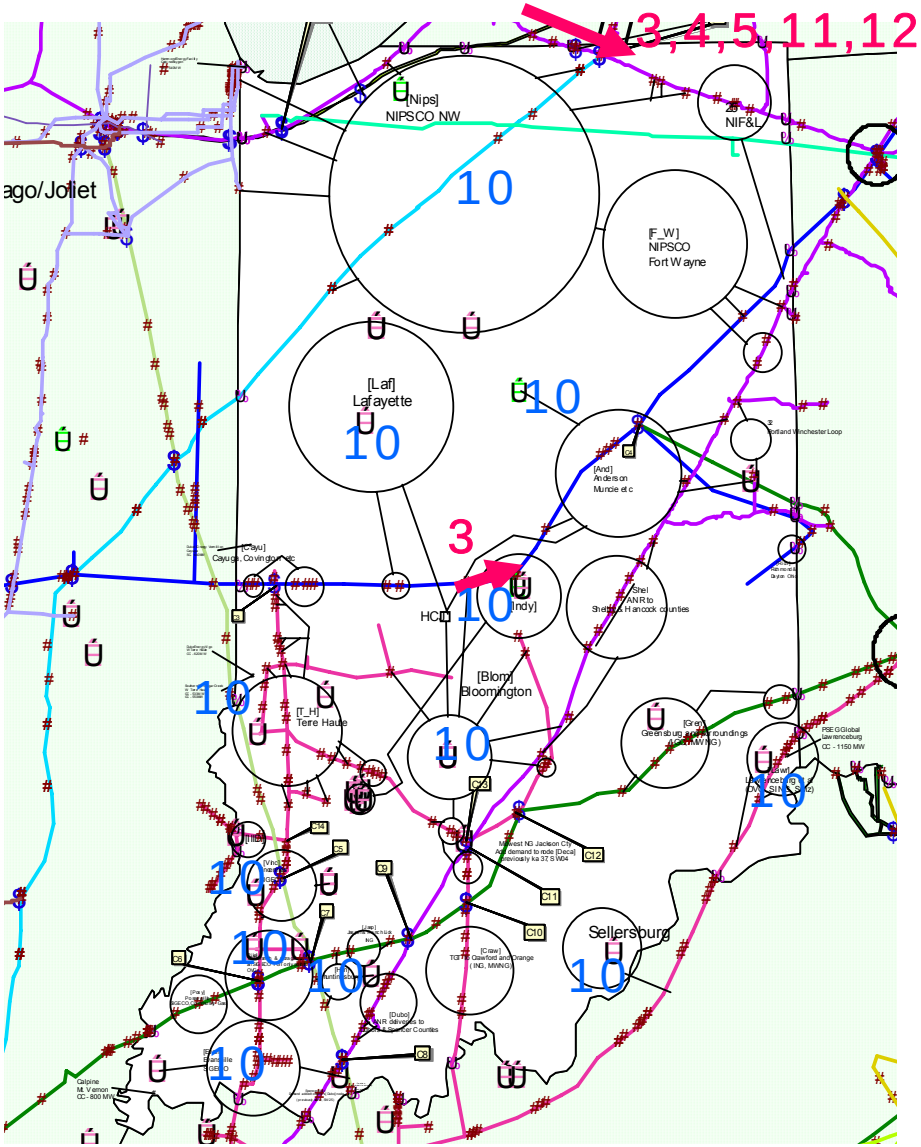
Base case

Regional electricity demand growth 1.8%



Above average demand in region

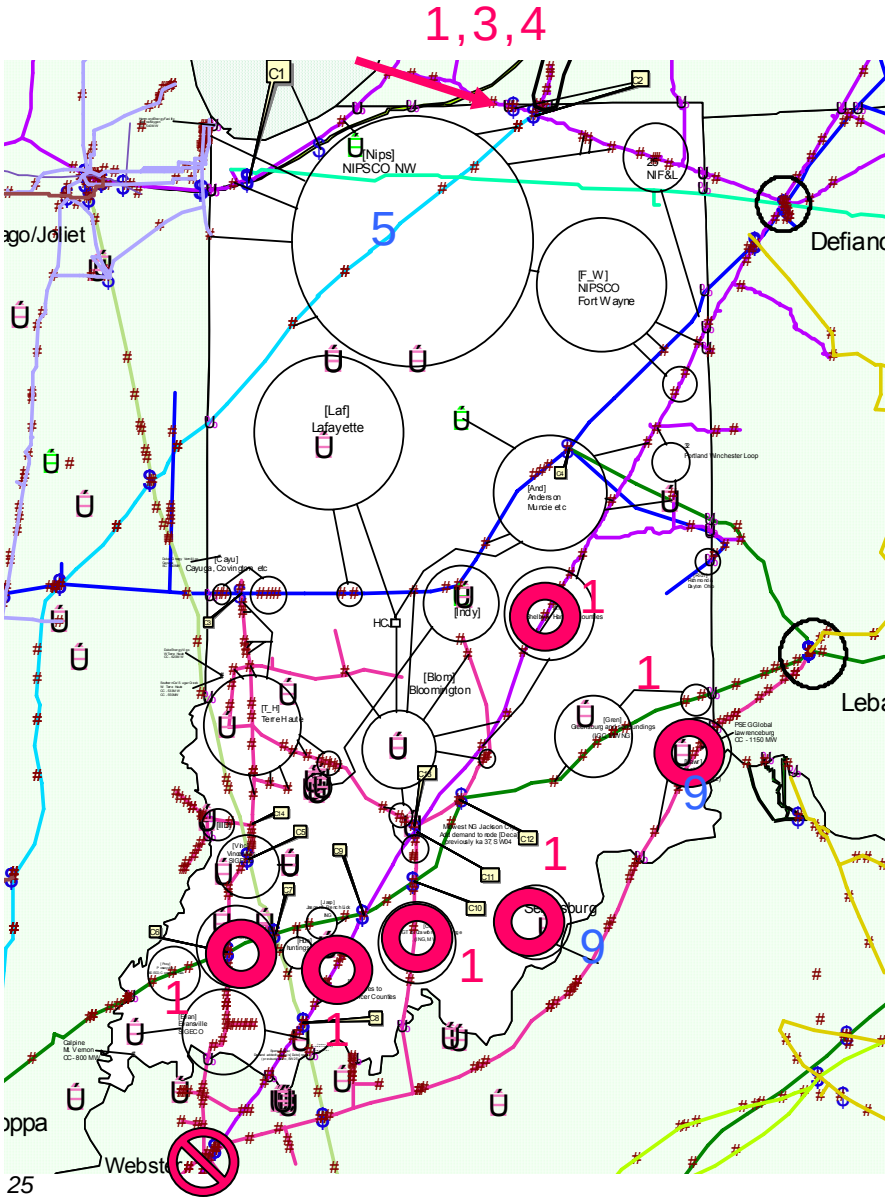
CDD HDD one STD above base
Regional electricity demand growth 2.2%



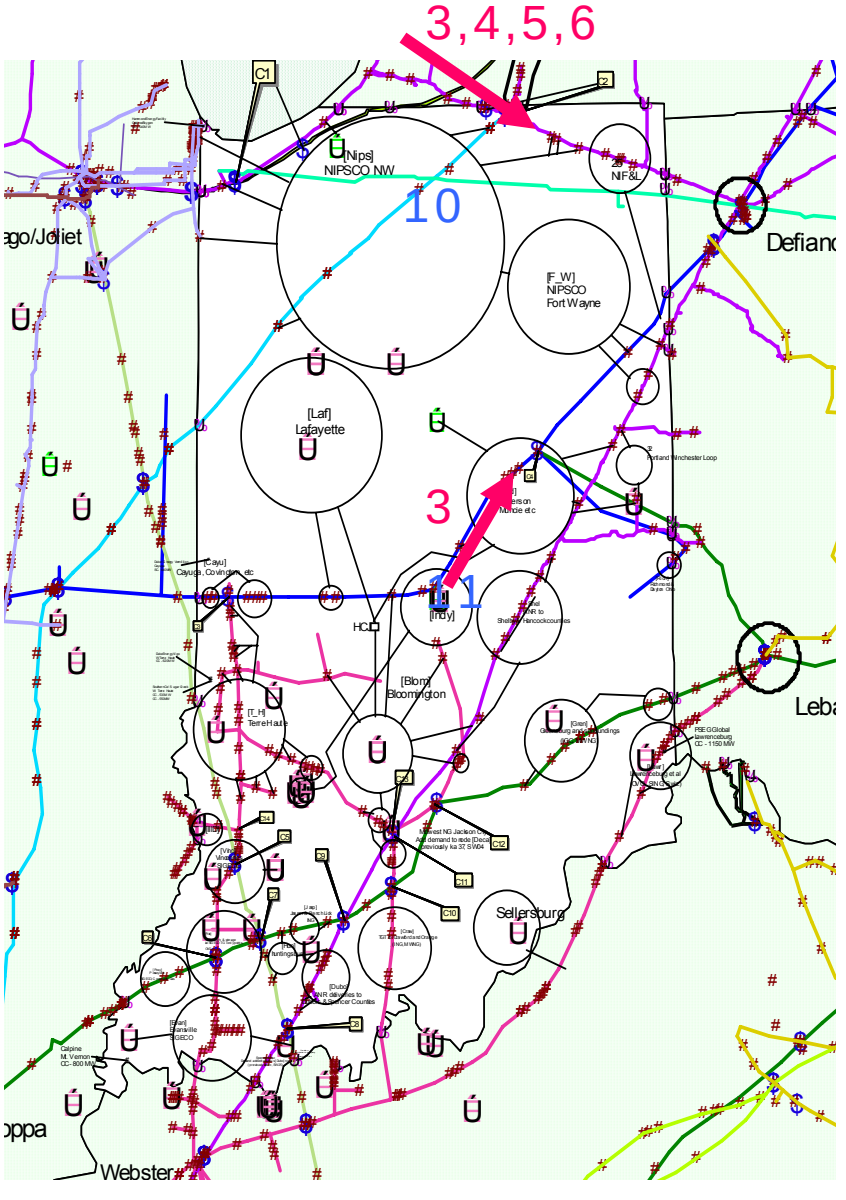
Unforeseen outage on the ANRP/TXGS interconnection at Webster, KY In January 2004

The nodes marked in red circles have unmet demand, but only in the month the disruption occurs

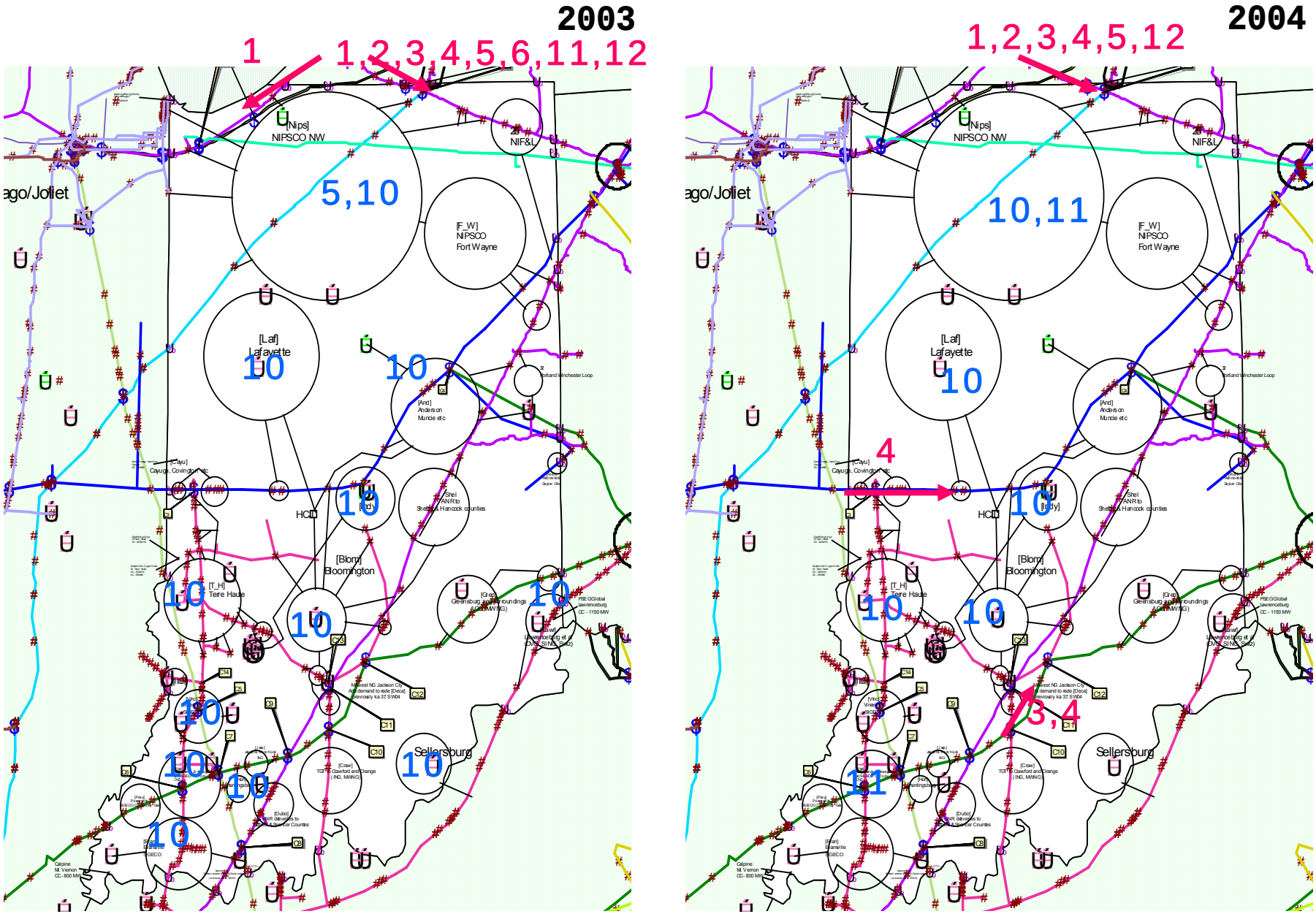
2004



2005

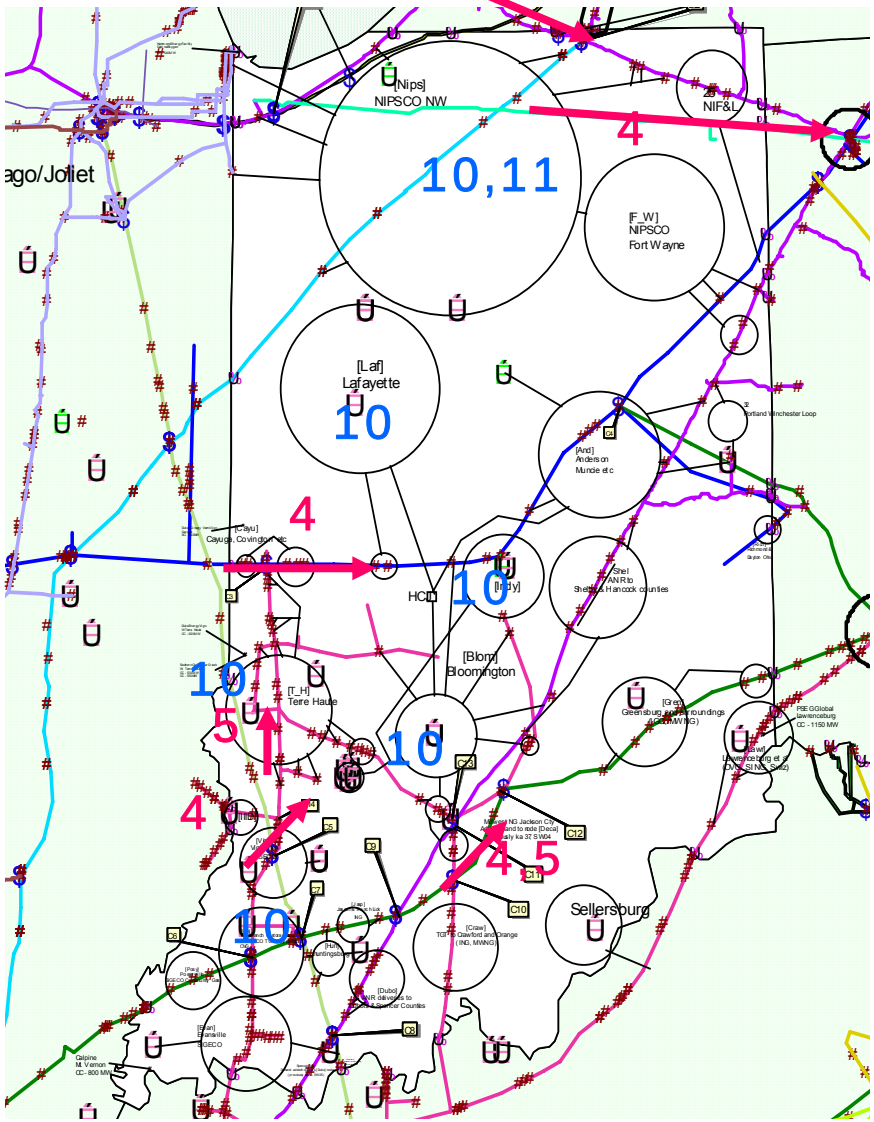


Extreme weather in the region plus all proposed merchant plants in Indiana

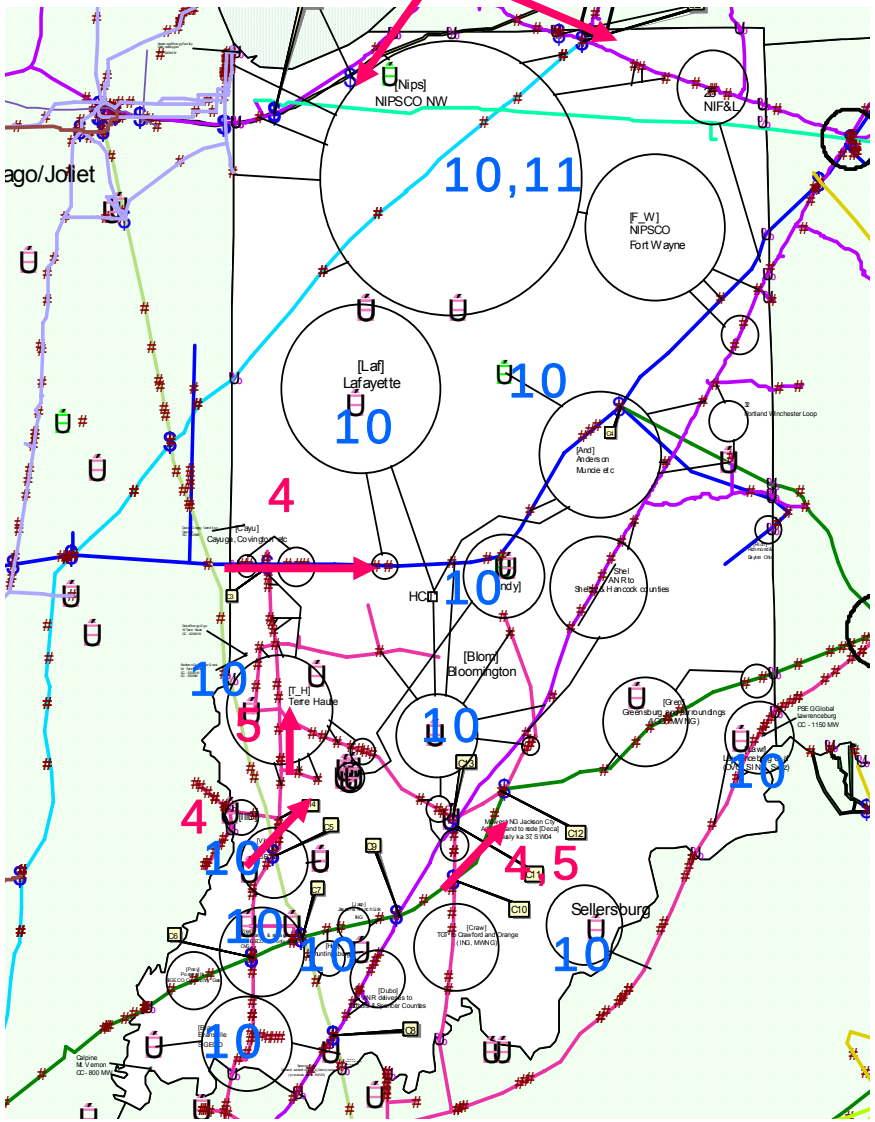


Extreme weather in the region plus all proposed merchant plants in Indiana (contd.)

2005



2006



FUTURE WORK

- Improve data quality
  - pipeline and storage capacity
  - local production
  - supply prices forecasts
  - demand forecasts
  - transportation charges
- Model price elasticity
  - demand
  - supply
- Model refinements
  - system pressure
  - model clock
  - storage facility constraints
    - maintenance
    - injection/withdrawal rates
- Model strategic behavior
  - transportation
  - storage
  - supply